

Abstract

Reactive mufflers, which incorporate a simple expansion chamber element, are widely used on automotive engines. Noise generated by engines, compressors, fans, etc. is radiated out into the atmosphere at the tail pipe end of the muffler and also as break-out noise from the muffler shell and the end plates. Either of these may become dominant source of noise depending on the application and other design factors. Hence, for proper designing of these silencer systems the axial transmission loss (TL_a) as well as the transverse transmission loss (TL_{tp}) should be high enough so that the net transmission loss (TL_{net}) will be adequate.

Transmission Loss measurements have usually involved use of an Anechoic Termination. In the first part of this work, an experimental method has been proposed which enables evaluation of the transfer matrix parameters and thence the axial transmission loss of an acoustic element or a subsystem of elements by means of the four microphone technique and use of the transfer function approach. Theoretical expressions have been derived for this experimental method which enables the evaluation of transfer matrix parameters and the axial transmission loss of an acoustic element without an anechoic termination being necessary. Another method, the reflection coefficient method, which enables, if a semi-anechoic termination indeed is available, an approximate evaluation of the transmission loss, has also been presented. The theoretical and the experimental

details have been presented for a reciprocal and symmetric acoustic system as well as for a general (asymmetric) acoustic system with stationary medium. For the general (asymmetric) acoustic element or muffler configuration the concept of reversing the test element has been adopted. The four-pole parameters and the axial transmission loss results obtained from the measured data are shown to be in very good agreement with those obtained from the theoretical and computational predictions. Further, the higher order mode effects, that can generally be captured using three dimensional numerical analysis, have also been observed in the experimental results, even though the peripheral formulation of the experimental method is based on one-dimensional wave theory.

In the second part, a typical simple expansion chamber muffler has been analyzed for its vibro-acoustic performance using Finite Element and Boundary Element methods considering the fluid-structure coupling for a given acoustic excitation. The resulting break-out noise from the muffler shell together with the end plates, and the transverse transmission loss (TL_{tp}) have been predicted using the above mentioned computational tools. An experimental investigation has also been carried out, to check the validity of the predicted results.

Towards this end, the incident sound power on the 'muffler proper' has been measured making use of the two-microphone transfer function technique. The radiated sound intensity or the break-out noise from the muffler shell and the end plates has been measured for the frequency range of interest using Sound Intensity (SI) technique on a cylindrical grid that surrounds the test element. Next, the radiated sound power has been obtained by making use of intensity results and the corresponding area of the grids over which the intensity is measured. Then the transverse transmission loss

has been obtained making use of the measured incident power and the radiated power. The computational predictions and the experimental measurements are found to be in reasonable agreement. Finally, parametric studies have been presented using numerical tools, with the shape and thickness of the muffler shell and end plates as parameters, as an aid to the muffler design process.